VATER: ITS WORK OF PURIFICATION.

BY ARTHUR RANSOME, M.A., M.D.

THE last two sessions I have lectured for the Manchester and Salford Sanitary Association on *Air*. The subject that has een assigned to me, in this year's series of Health Lectures, is *Vater*, and it would be hardly possible to choose a more important r nobler theme on which to discourse.

It is indeed noble, in every sense that the word can be used. Vater is one of the purest substances in nature, as Professor Vanklyn, the eminent chemist, has pointed out. Even the very oulest varieties of drinking water possess a high degree of purity, hen compared with other substances found in nature. It is rare r a chemist to meet with chemical compounds that do not contain e one-thousandth part of foreign matter, and even impure water ontains less than this. This is well shown in the following able :—

ANALYSIS OF WATER.

SOURCES.		PARTS PER MILLION. FREE AMMONIA.		PARTS PER MILLION. ALBUMINOID AMMONIA.
Thames	Chelsea	·01	...	·07
	Southwark	·03	...	·16
	Lambeth	·02	...	·14
New River		·02	...	·08
Lea		·03	...	·09
Kent Company		·01	...	·02
Manchester		·01	...	·06
Chester		·01	...	·07
Glasgow		·00	...	·08
Guildford		·00	...	·01
Effluent Sewage		16·20	...	·90
London Pumps		3·75	...	·18
		7·50	...	·26
Well at Windsor		1·20	...	·84

If it were possible to assign a position of pre-eminence to certain of the chemical elements, it would be given, I think, to the two of which water is composed—Hydrogen and Oxygen—the most refined and pure and the most powerful agents of all simple bodies. These gases have, until lately, shown themselves to be the most difficult of all to conquer by physical means. Although, when combined, they form the limpid fluid that is now our subject, they were the last of all the gases to be coerced into the liquid state. I may say, incidentally, that it is by the combination of these two gases that the most brilliant light known, the oxyhydrogen light, is produced.

Water might also be exalted to a high rank amongst the elements, from the vastness of its extent, seeing that it occupies at least two-thirds of the whole surface of the globe, and a great proportion of the depths of the atmosphere, and that it forms by far the largest proportion (about three-quarters) of the frames of all living creatures.

But it is the noblest of all in its great usefulness. "Water is the principle of all things," said Robert Boyle, the philosopher.* "*Aqua, instrumentum Vitæ*," said Boerhaave; and in truth it is the medium in which all life subsists, and without which no vital action can go forward. Follow it in its course throughout the universe and you will concede its right to be thus entitled.

We see its vapour rising from the surface of watery areas—varying in quantity with the temperature, from 20 cubic inches per square inch, in the colder regions, to 300 or 400 cubic inches in the tropics. This vapour, which is at first invisible, and which is not much more than half the density of the atmosphere (about six-tenths of its weight), helps the air thus charged to rise into the higher strata of the aerial sea. There it is condensed into the variously formed clouds that float about, above, below, and around us.

We know, even now, but little of the balancings of the clouds, but physicists tell us that this vapour has an important duty to perform in retaining the warmth of the earth. The radiant heat of the sun passes readily through it to the soil and rocks of the globe; but when this heat is deadened and unaccompanied by light it cannot again so easily pass away. Professor Tyndall has called this the rachet-wheel action of the atmosphere, and it is due to the aqueous vapour.

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*Op., vol. iii., p. 284, "The Sceptical Chemist."

It is, indeed, impossible to view our subject in all its many aspects, and we must therefore, to-night, limit ourselves to its sanitary relations, and choose only one out of even these—namely, "its work of purification."

We know comparatively little also of the chemical processes that go on in the vast laboratory of the sky; but we may be sure that much of the work is purifying in its nature. Carried along with the watery particles are many kinds of refuse cast off from the surface of the earth—some of it inanimate, dead, and putrefying, other portions teeming with living organisms. Dr. Burdon Sanderson has shown that the much dreaded Bacteria, the microscopic forms that produce putrefaction, and sometimes, perhaps, disease, reside chiefly in the aqueous particles of the air.

These all pass with the rising vapour into the clouds; they are stirred into their depths by the winds; they are attacked by the ever-active agent oxygen, or its product, ozone; they are noiselessly destroyed by the electricity that pervades it, or are burnt up in the flashes of stormy lightning. The result at least is known to us. From time to time the clouds discharge their contents, distilling gently, as in a Scotch mist, or pouring down in the torrents of a tropical rainfall. It has been calculated that 90,000 cubic miles of water are thus annually returned to the surface of the globe, and of this amount 30,000 cubic miles descend upon the land.*

But this quantity of water contains one and a half million of tons of ammonia, or hartshorn—the substance that is so valuable to farmers as a manure. It is, in fact, sewage matter, and is the product of the action of the atmosphere upon the refuse material, carried into its vast depths. Surely, this fact alone testifies to the enormous extent of the purifying labours of water.

But the rain not only acts as a scavenger of the sky, it also washes refuse from the surface of the earth, either carrying it down to fertilise the ground, or sluicing it along channels, streams, and rivers, until at last it reaches the ocean. It is probably owing to this fact that rainy years are so often healthy years. Amongst the many discomforts that a wet season brings, let us, at least, remember that there is much good mingled with the evil; and—in answer to the taunts of those foreigners who think Englishmen live in a constant drizzle and mist, and never see the sun—

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* Another calculation, by Dr. Lombard, is that about 50,000 million gallons are thus annually poured on to the earth.

let us point to our comparatively low death-rate, and ascribe, at least, a portion of this advantage—as well as our green fields—to the frequent showers and rains that wash away impurity.

I must not stay to speak of the material service done by underground water, its assistance in disintegrating and oxidising organic matter, and its work of self-purification. We must now turn from the macrocosm of the world to the microcosm of the human body, and learn what important work is therein carried on by this valuable fluid.

The whole nutrition of the body is, in truth, accomplished by a system of water carriage. Claude Bernard, the great French physiologist, has said, with truth, that air-breathing animals are only animals that have got outside of the water: "All the organic elements that form our frames are necessarily aquatic in their nature, and it is only by an artifice of construction that our bodies can exist and move in dry air."

The living tissues are all bathed in fluid, and they are nourished by the blood in which they are immersed; they live there, in fact, as aquatic animals live in the water.

But perhaps the most important work that is carried on by the water contained in our bodies is the work of purification.

The watery fluid, the blood, is forced by the contraction of that wonderful pump, the heart, through a system of branching tubes or canals called arteries. It then passes more slowly through little hair-like vessels called capillaries. Some of them are so small that 3,000 would lie side by side in the space of one inch, and so numerous, in many parts of the body, that a needle's point could not be passed amongst them without wounding some of them.

This "living fluid," as it has been called, carries with it all kinds of nourishment for the tissue through which it flows.

To employ, yet again, a much-used simile, like the inhabitants of the water-pierced cities of Amsterdam and Venice, everything that is needed for sustenance comes along the canals that surround them, borne along, either in the blood itself, or in the microscopic bodies called corpuscles. As Dr. George Wilson says, in eloquent language:—

> "Those wondrous crimson barks or blood cells which navigate the arteries are keen traders, and follow the rule of the African rivers, where sales are only effected by barter. But they add to this rule one peculiar to themselves, which neither civilised nor savage man cares to follow, namely, that they give away new goods in exchange for old. Here the traffickers on the Red River deposit fresh brain particles to replace those which

the immaterial spirit has sacrificed to the expression of its thoughts." And "as fast as the blacksmith wastes his muscles at each blow, the mariners of the river of life in his veins barter against the spent cordage of his arm new flesh particles to make it strong as before. They restore to its integrity the exhausted auditory nerve of the musician, give the painter a new retina, the singer a new tongue. Whenever, in a word, the million lamps of life which keep up its flame at every point of the body have burned to the socket, they are replaced by freshly-trimmed ones. Nor is it here as with the barter of Aladdin's lamp—the new lamp is, in this case, the magic one—the Genie has departed from the old."*

In addition to the work of carrying nourishment to the several parts of the body, the blood has, as Professor Wilson has told us, to convey away the refuse material cast out by the tissues. It does this by means of the return currents of blood contained in another system of channels called the veins, and until the impure blood that these contain has passed through various kinds of purification it is not allowed to return into the general circulation. The veins have sometimes been compared to the drains and sewers of a town, bearing along their channels the debris and filth cast out by the inhabitants. In a certain sense the simile is an apt one, but it must not lead you to suppose that venous blood is in any way comparable to the foul contents of the underground channels of a modern city.

So great is the care taken in purifying the stream that no accumulation of sewage matter ever takes place in our veins, in a state of health; and there is only a very trifling difference in the solid and fluid contents of the blood contained in the arteries and in the veins. The chief difference, as we shall see presently, is in the nature of the gases they respectively hold in solution. The purification of the blood is effected in several ways, in all of which, however, water plays an important part, and it will be worth our while to examine their processes a little in detail. You have probably—most of you—heard of the different modes of "treating town sewage," as it is called; you have seen the words, "intermittent filtration" with utilisation of manure; the precipitation of solid matter by various means; you may have heard of purification by animal charcoal, and other disinfectants; and lastly, of the plan that is partially carried out in Manchester, the destruction of the refuse material by means of heat.

But in the human body, not one only, but all these methods are practised, and practised much more fully and perfectly than has hitherto been possible in any community of human beings.

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* "Edinburgh Essays." Art., "Chemical Final Causes."

1. A large portion of what we may term sewage matter is not allowed to pass into the main sewers (the veins) at all. There is a special set of tubes and other apparatus called the absorbent system that at once receive any very obviously impure material. Like the scavengers of our streets, or, perhaps still more, like the *chiffonniers* of Paris, who go about with baskets on their backs and a light fork in their hands, picking up all kinds of rags, soiled paper, bones, bits of metal, &c., so these absorbent vessels select certain portions of refuse matter, and carry them to sorting stations—the lymphatic glands—where they are dealt with before the liquid they contain is permitted to pass into the veins. A large part of the treatment of this first portion of the sewage is, indeed, a kind of filtration—filtration as through animal charcoal—and the effluent water is not permitted to pass into the blood until it is quite free from impurity; it passes first to one and then to a second or more of these filtering stations, according to the amount of impurity the fluid contains.

Some of you may, perhaps, have suffered at one time or another from a poisoned wound in a finger, or from an unhealthy ulcer on a limb; and if so, you will probably have been made aware of the existence of this elaborate system of purifying apparatus. You will first have noticed an unhealthy appearance about the wound, and then some tenderness and swelling in the neighbouring absorbent glands; then, if the amount of the impurity was great, or was virulent in its character, you will have seen red lines coursing along under the skin, and leading to another swollen and tender gland in the armpit or elsewhere; and then, if the charge of poison is very great, it may cause a gathering in the site of this gland, or it may even overflow into the blood and thereby produce shivering, severe fever, and true blood-poisoning, as it has been called.

Again, we may perhaps find another instance of the preliminary treatment of sewage in one part of the work of the liver. This organ certainly carries on some very important manufactures, notably starch and sugar making, and helps to elaborate the blood itself. But it is also a genuine excretory gland. There is a special system of blood-vessels set apart for conveying all the blood from the stomach and intestines to the liver, and though the exact nature of the work done in this organ is not yet settled, it is probable that this blood is filtered, and to a great extent purified in its passage, by a process analogous to some of the sewage precipitation works of our large towns.

2. But still none of the fluids that have been so far mentioned are allowed to pass into the general circulation. They are indeed poured into the veins, and these join all the other blood coming from every part of the body, but all the sewage has now mixed with it a large quantity of carbonic acid gas or smoke that must be got rid of, and at the same time the still impure stream has to be exposed to the purifying influence of atmospheric air.

This is accomplished in the lungs. We have nothing now to do with the wonderful influence of the oxygen of the air upon animal life. We know that it has to be carried to every tissue of the body, and that its intense activity liberates the energy stored up in animal nerve and muscle, and, indeed, in every organ of the animal frame ; but we have now only to note the fact that this action is a kind of moist combustion, and that the result is the formation of a noxious smoke or gas that must be got rid of at once or the animal will soon die.

Every drop of venous blood, and also the purified lymph contained in the absorbents, passes ultimately to the heart, but to its right half only, and from thence it is pumped into the lungs, whence it meets with constantly renewed and carefully warmed air. Here it exchanges the noxious smoke of the animal furnace for fresh, pure atmospheric oxygen, and changes its colour from a dark purple to the bright-red hue of arterial blood.

3. These purifying processes, in all of which water takes an important part, provide for the most pressing needs of the body. They cannot stop for even a few seconds without danger to life ; but still this is not all that is done to purify the living stream—water still has more work to perform. There are various salts, the products of almost complete decomposition, and these have to be taken out of the system from time to time, and to be sluiced away by streams of water. This labour is undertaken by the kidneys and by the skin, and beautiful exceedingly is the machinery by which in each case it is accomplished.

It is, in truth, no small advantage attached to the study of medicine that it makes us acquainted with the beautiful and marvellous works of the Creator. As Coleridge says : "In wonder all philosophy began, in wonder it ends, and admiration fills up the interspace." I can only now give a very brief sketch of these water-works of the body, but they would well repay any one who would undertake their closer study.

The kidneys consist of a series of wonderfully coiled and twisted tubes, surrounded by blood-vessels ; the salts arising from the destruction of animal matter are extracted from the blood by cells lining portions of these tubes, and then these salts are washed away by water that filters through the beautiful coil of vessels contained in what are called the Malpighian bodies. I have here a representation of this mechanism. You will notice that the duct or tube ends in a sort of pouch or *cul-de-sac*; in this a blood-vessel is twisted up, and it is so arranged that a difference of pressure in this vessel will modify the quantity of water filtering through it. The mode in which this is done is far too intricate for us now to consider, but it may be sufficient for you to know that the watery fluid from the blood washes away into a place of safety the decomposed and decomposing elements of the body.

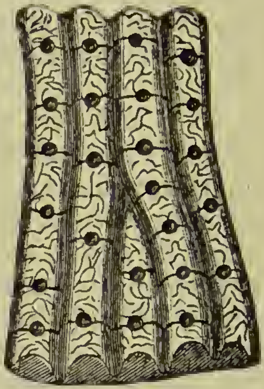

FIG. I.—MAGNIFIED PORTION OF THE SKIN,

Showing the openings of the sweat glands.

The sweat glands of the skin also remove from the blood some refuse material. They are not very dissimilar in their construction from detached portions of the kidneys, but they have to serve other important functions as well as that of excretion, notably the regulation of the heat of the body. They are, therefore, rather differently arranged.

The skin is, in fact, composed of a texture that would be quite impervious to fluid if it were not pierced with a multitude of little holes. Its outer layer has been called the corky layer, from this fact, but the ducts of the sweat glands pass through it and pour their contents on to its surface.

It has been calculated by Erasmus Wilson that there are nearly 3,000 of these pores in each square inch of the skin; or, in an average-sized man, about seven millions over the whole body.

Each duct passes inwards for the distance of about one-third of an inch, and then instead of enclosing a coil of vessels it is itself coiled up, and its surfaces are surrounded by an abundance of hair-like arteries and veins. From the blood that these contain, its tiny workmen, the secreting cells, extract the constituents of the fluid that we call sweat, or perspiration.

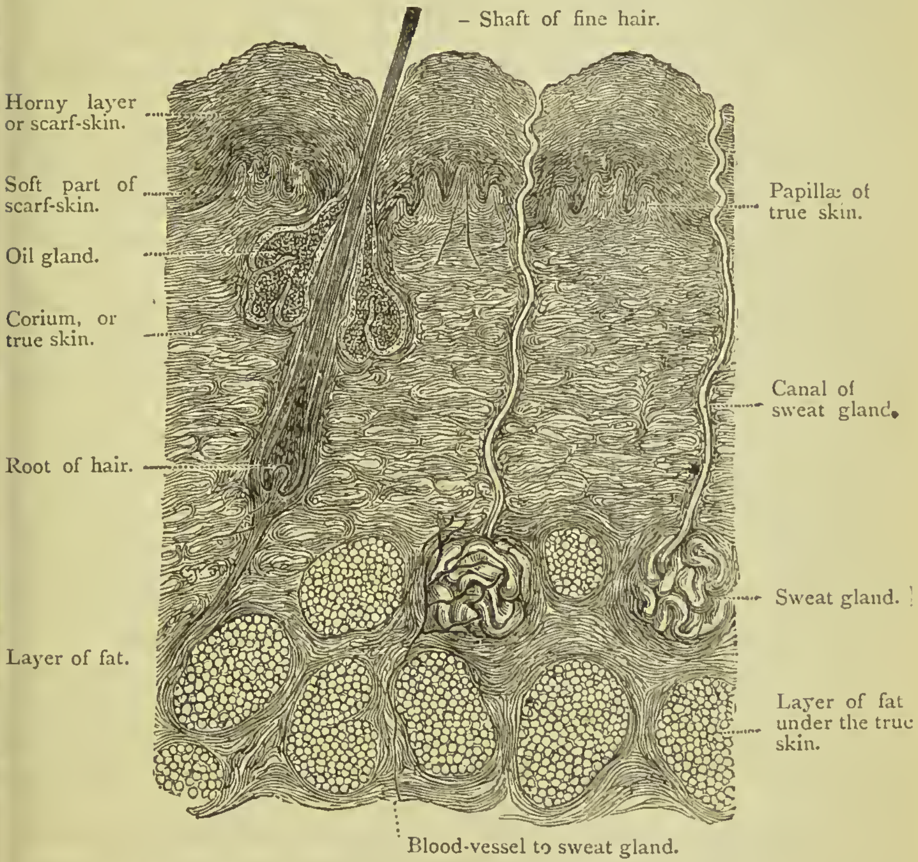

FIG. 2.—MAGNIFIED PORTION OF THE SKIN.*

It will be evident, however, from the diagram, and from the description that I have given, that as all these ducts discharge on to the surface of the body, and not into one receptacle, as the kidneys do, their openings and their secretions are to some extent under the control of the individual. Their mouths might, for instance, easily get stopped up by dirt or in some other way. And it is very important that the secretion should have free vent. When the greater part of the skin of an animal is covered with an impervious varnish it soon dies, with symptoms of poisoning; and one of the chief dangers in extensive burns of the skin, even when very superficial, arises from this cause—the imperfect separation from the blood of effete animal matter.

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* The openings of the sweat glands should have terminated on the tops of the ridges.

It is not wonderful therefore that great care should be taken in the construction of the skin to prevent any stoppage from taking place.

1. The ducts open on to the top of little ridges, with channels running on each side of them. The fluid can thus more readily get away, and if any substance were for a time to lodge on the top of a ridge it would soon be rubbed away in the movements of the body against clothing or other objects.

2. To facilitate this the scarf skin on these ridges is made of minute scales, that are regularly shed with the growth of the skin. Every day and every hour some of these scales are crumbling away from the surface of the body.

3. The openings are directed slantwise, almost like valves, so that water and vapour can readily pass out, but it is difficult for anything to get into them.

4. Even if this were not sufficient, the tubes pass down into the soft layers of the skin, in a sort of spiral fashion, partly to prevent compression and to permit of a certain amount of stretching, partly to give more space in which the vapour can collect.

Such is a brief outline of the many complicated processes that are continually being carried on by water in this body of ours, in order to preserve its vital parts from contact with anything that might do it pain. And now, what is the lesson to be learnt from it all.

In almost every case, in each of the many varieties of work we have contemplated, it is a lesson of the necessity for perfect cleanliness. If cleanliness be not next to godliness, at least it is next to healthiness. We shall do well to lay it to heart, and I will point out a few of the practical deductions to be drawn from the history just told.

Some of these deductions will have only a personal bearing; others have also a relation to the public health, and may well be pondered by those in authority.

1. From what has been said it will be evident, I think, that there must be for health an abundant supply of water of good

quality. For the needs of the body itself we require, in food or drink, about four pints of water daily, and to keep it clean and to cleanse thoroughly all its surroundings, and to flush the drains and sewers, any quantity less than 12 gallons per day is insufficient. This calculation, moreover, makes no provision for water-closets, and a very small one for baths. The ancient Romans had an allowance of no less than 300 gallons a day of excellent water for each inhabitant, and I should rejoice to see the day when an almost equal provision was made for all our large towns. The late Canon Kingsley showed some years ago that in England we have no need to stint the supply; and more recently, at the Conference on National Water Supply, convened by the Society of Arts (May, 1879), it was shown by several engineers that there would be no real difficulty in getting an almost unlimited supply of water for every inhabitant in the kingdom. (See Report, pp. 7, 66, 85, 90, &c.) Fortunately, in this district, we have a fairly abundant supply of excellent water. Amongst many other good sanitary works carried out by the municipal authorities, we may place foremost their efforts to give the inhabitants plenty of pure soft water, water good for drinking, good for washing and bathing, and good for manufacturing processes. There is little need, therefore, here to dwell long upon this point; but in order that you may know how great a boon has thus been given to you, I may just for a moment point out how much advantage to the public health has already been obtained from it. Since the completion of the waterworks of Woodhead (1) there has been no outbreak of cholera in this town, although this disease has twice visited the country in the interval; (2) there have been comparatively few deaths from diarrhœa, such as could be traced to bad water; (3) there has been very little typhoid fever, except in the suburbs, where there was bad drainage; and (4) there has been little or no typhus fever. That these benefits are, at least, partly due to the good water supply may be seen from Dr. Buchanan's table, showing the influence upon the health of towns produced by reforms in the direction of drainage and water supply.

2. Next to the subject of the quantity comes that of the quality of the water which we use. This last is, indeed, of almost more importance than the first. This is not the place to speak of the diseases produced by drinking impure water. It is far too vast a subject to be dealt with cursorily, and demands special treatment, but it will be readily understood, after what we have seen of the circulation of water within the body, how necessary it is that the

fluid we present to the delicate textures of the body should be of the purest character possible. Nearly all the water we swallow passes in a very few minutes into the circulation, and is carried throughout the body in less than a minute, circling through the greater part of it over and over again in a very short space of time. In spite of the great precautions that are taken to prevent impurity getting into the blood therefore, it may easily occur that if it is contained in water it will escape the notice of the watchful guards, and may lodge in some of the glands, if not in the tissues of the body itself. There it may, and often does, produce disease, and fluids, contaminated with organic poisons, have frequently been shown to have produced diarrhœa and dysentery, marsh fever, cholera, typhoid fever, scarlet fever, and diphtheria. Pure as water naturally is, so far as regards the actual proportion of foreign matter present in it, its impurities are of the utmost consequence to health. We daily take into our bodies, as I have said, three or four pints, at least, of water, and if this contains even a few grains per gallon of an injurious substance, it will in time sap the strength and lead to disease. It would be impossible now to describe fully the various impurities of water. It is important, therefore, to indicate some of those you are likely to meet with, and that might be injurious to health, and I shall have briefly to mention how you may know a good water from a bad one.

We may disregard for the present the various mineral salts derived from the sources of the water supply. No doubt a hard water is very difficult to wash with; it takes a great quantity of soap to get things clean, and is therefore uneconomical; it is also bad for many cooking purposes—for making tea, or soup, or bread, and so on; but unless the solid particles are in very large proportionate amount it does not usually affect the health.

What are of far more importance are the substances that may get into the water after it has left its moorland channel or its rocky bed; and chief amongst them are metallic contaminations or impregnations with organic matter. The metallic poison that most commonly gets into water is lead, and it is as well that you should know that the pure soft water supplied to Manchester acts strongly upon this metal. An inquiry many years ago, set on foot by this Association, and carried out with great zeal by the late Professor Crace Calvert, proved this beyond doubt. In susceptible persons one-tenth of a grain per gallon has been known to produce lead poisoning, with all its train of misery, the general loss of health, the colic, the palsy of certain muscles, and other symptoms.

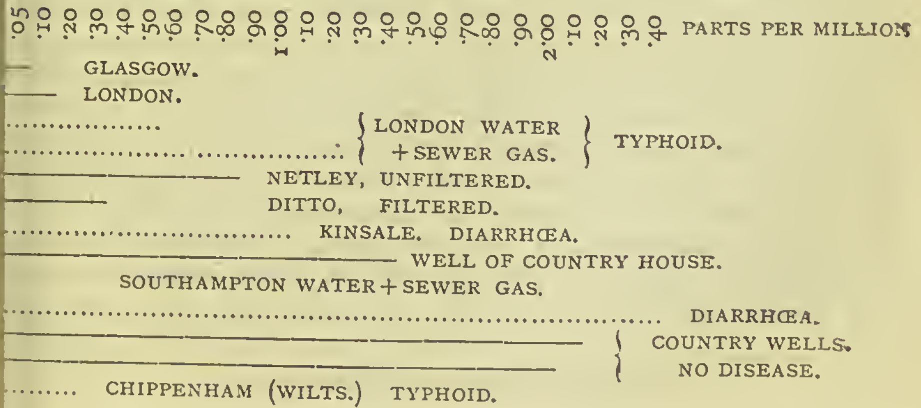
No water, therefore, should ever be drank from a leaden cistern, or even after it has rested for some time in a leaden pipe. I well remember one well-marked case of lead poisoning which could not be traced to any contact with a leaden cistern or leaden utensil, and only one person, the lady of the house, suffered from it. She alone was attacked, because every morning she had a cup of tea before rising, and the kettle used was always filled from a leaden pipe the first thing on the servant's coming down in the morning.

Water may also get injuriously contaminated by zinc, or brass, or copper, but these are less common modes of poisoning. A much more serious thing is pollution with organic matter, and this not from any intrinsic badness in all kinds of organic matter, but simply because it may have mixed with it the germs of specific disease—or because it is a fit medium in which such germs may sustain life, or even may grow and multiply. We daily take with impunity large quantities of organic matter mixed with water, in the form of soup, tea, coffee, &c., but this is harmless, from not containing specific germs.

Water, in its passage through earth, may also take up organic matter of a perfectly innocent description; and hence we find that disease by no means always accompanies a water contaminated with organic matter; but if organic matter can get into a water from the neighbourhood of dwellings, so can the specific poisons of which I have spoken. This is well shown by the following diagram, which I have taken from Professor de Chaumont's work on "State Medicine":—

ALBUMINOID AMMONIA IN WATER.

The dotted lines indicate the presence of disease; the length of the lines the relative amount of impurity.



Hence it is that chemists always condemn any water that contains organic matter not traceable to the original source of supply, say from a peaty moor.

There are many elaborate processes that are employed for the complete analysis of water, and those invented by my friend, Professor Wanklyn, are very admirably adapted to the purpose; but I cannot describe them now, and I may say that even the best of them are liable to error, unless the previous history of the water is taken into account—its origin, its subsequent course, and possibility of contamination.

There are also some very simple means described by Mr. Hartley*, that may be adopted by any one who wishes to ascertain whether the water he drinks is tolerably free from impurity, and these I will now describe to you.

1. Good water should be clear, bright, almost colourless, and without sediment. This may be ascertained by filling with it a clear white glass water-jug or water decanter that has been well rinsed, not wiped, out. Look through the water at the bright daylight in different directions, and if it have little organic particles floating in it—if it be cloudy or hazy—you may be sure that it is not quite right. Any greenish tint will show the presence of vegetable matter; and a brown or yellowish colour, unless it comes from peat or iron, will show pollution with animal substances. If you cannot read printed matter through a depth of at least 18 inches of water, it is not sufficiently pure for drinking purposes.

2. Drinking water should be sparkling, have a pleasant taste, and should have no odour. Any water with a decidedly nasty taste, or with a saltish or sweet taste, is unfit to drink. Rinse a wine-bottle out with the water, put in a clean cork, and shake it up. If any smell is perceived on applying the nose to the uncorked bottle, the water is bad. If such be not the case, then place the bottle aside for a week or a fortnight—corked, and in a warm situation—in summer, out in the sunshine will be warm enough. Then shake, and smell as before. Any disagreeable smell is a bad sign. By this means, water perfectly bright and clear has sometimes had its source of pollution detected. Surface water from cultivated land, for instance, sometimes acquires the smell of a pond or ditch—what may be described as a "weedy" smell. It is faint, but quite perceptible. Water from a stable, and, in other instances, water from sewers and from gasworks, have revealed their presence

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* "Manual of Health—Water," p. 70.

in clear and tasteless well waters, when tested in this manner. Impure water may often be purified by passing it through a good filter made of animal charcoal, silicated carbon, or spongy iron ; but if it comes from a suspicious source, it is always better to boil it as well, before putting it into the filter. The filter itself must always be carefully watched and periodically* cleansed, in order that it may not itself become a source of danger. A simple form of filter, described by Professor de Chaumont,† is made "by putting some animal charcoal over some fine gravel, into a common flower-pot. If animal charcoal is not to be had, "common earth heated *red hot* in a shovel and allowed to cool, will answer very well" for a time.

There is, however, one other important mode in which water is often adulterated that I must also mention, and that is, its mixture in various proportions with alcohol. I am no teetotaller, but I should be doing wrong if I did not point out the consequences of constantly mixing the pure fluid, water, with certain forms of spirituous liquor. There are many who never touch unadulterated water. They are like Mynheer Van Dunck, "of water alone they drink no more than a rose supplies, when a dew-drop lies on its bloom on a summer morning." But I need hardly say they do this at their peril. Thanks to the rapidity with which much of this spirit is got rid of by the various purifying agents I have mentioned, some few people receive little harm from imbibing the noxious substance, but it is a very small percentage who thus escape. It has now been shown by men of science, beyond all shadow of a doubt, that when alcohol does get into the system it checks vital changes, diminishes the energies of the body, and partially, and sometimes wholly, paralyses certain parts of the nervous system. If continually imbibed in more than a certain most moderate quantity, it gradually hardens certain of the tissues of excretory glands. "It fastens like a vulture on the liver" (Dr. Farr), lowers the whole tone of the body, and renders it liable to certain low forms of inflammation. Owing to its sedative and other physiological powers it is, indeed, a valuable medicine ; but taken even in comparatively small quantities, as an habitual drug, it almost certainly shortens human life. This statement is proved by the results that have been obtained by the United Kingdom Temperance and General Provident Institution. This society, which has been established for 35 years, has for 29 years kept distinct the receipts and expenditure, and thus the profits, of the temperance (*i.e.*, total abstaining) and general sections. It is a large commercial undertaking, with nearly £2,000,000 of capital, and there are about an equal number of members in each section. The members in the general section are selected as carefully as possible, so as to avoid persons of intemperate habits, and the bonuses in this section have been larger than those granted in the majority of proprietary offices. The calculations are made by scientific, and therefore unbiased, actuaries, and the results are that the profits are about 20 per cent greater in the temperance than in the general section. The total abstainers live longer, pay more premiums, and receive nearly double the bonus that is paid to the moderate drinkers. These are striking facts, and though they may not prove the need for total abstinence, they show very clearly, either that what is supposed, by most men, to be strict moderation in drinking is more than is good for them, or else that amongst moderate drinkers a good many are to be found who drink to such an extent as to shorten their lives.

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* Every few months.

† "The Habitation in Relation to Health," p. 61.

3. The next point on which we may derive valuable information, from a study of our human waterworks, is the hygiene of baths and bathing. We have seen the care that Nature takes to keep the pores of the skin free from all impediment, and this care undoubtedly makes it more difficult for dirty people to poison themselves than would otherwise be the case. Still, as most medical men can tell you, it is quite possible to frustrate all her good intentions. You may lay successive strata of dirt so as gradually to fill up the channels between the ridges, and then another coating of the same material, well plaistered on, will make a uniform plane, free from the rows of gland ducts. Only here and there will it be possible for the pressure of the vapour within to force its way out.

Another method of injuring the action of the skin is just the converse of the one now noticed. In the beautiful self-acting machinery for the skin, it is provided that when the surface is kept warm, vapour and fluid are poured forth abundantly, in order to cool it, and this is generally so managed that there is no excessive discharge of fluid, not much more than is necessary, in order that by its evaporation it may cool the body to its natural temperature. Many people, however, so heap clothing over certain portions of skin that it loses its natural functions and becomes so relaxed as to have its pores always open. On the least exertion or excitement perspiration pours out in streams, and a cold sweat covers the surface of the body. This is especially the case when the clothing is of a close, impervious texture, but any localised excess of covering, as in the use of the so-called "chest protectors" and "bosom friends," is sure to relax and weaken the part instead of strengthening it, and the foul substances that collect on the garment produce an impure atmosphere that gives forth its fumes just in front of the mouth and nose. The continual inhalation of such air is far more likely to produce consumption than the chest protector is to prevent it.

Against both deficiency and excessive action of the skin the regular use of cold water, especially in the morning, is an infallible remedy. The sudden shock of cold applied to the surface causes the little vessels first to contract and send the blood onwards to the heart, and then, as if it had drawn back, in order the better to leap ("*Réculer pour mieux sauter,*" as the French say), it rushes back into the skin. A ruddy flush suffuses it, and a glow of warmth is felt throughout the part. All the little pores are freed from the accumulation of dirt, and a healthy natural action of the skin is the result.

4. The mode of dealing with refuse matter employed in the corporeal body may well help us to see how it should be dealt with by the corporate bodies who bear rule in our towns. In the former there are no accumulations of decaying and refuse substances permitted to take place. There is nothing analogous to the reeking ashpit, with its manifold abominations, sending forth poisonous matters into the air. In both Manchester and Salford, I am happy to think, these receptacles are rapidly becoming things of the past; but what has unfortunately come to be called the "Lancashire Midden System" is still in vogue in many places in our immediate neighbourhood.

In the healthy human body, also, no refuse matter, whether dry or wet, is ever allowed to be retained, even for a short space of time, without being protected from decomposition by some antiseptic. The contents of the bowels are preserved by the bile resins, and even the secretion from the kidneys contains some analogous extractive matter that will keep it from putrefaction for at least twenty-four hours after its exit from the body. This is a refinement that has not yet been generally introduced into the management of towns refuse. It is, I believe, partially carried out in the system now adopted in Manchester and Salford, and the utilisation of the various substances now stored in the Corporation works is admirably conducted by a series of processes, most of them, I believe, invented by Mr. Alfred Fryer; but a little further study of the perfect contrivances used in the human body would assuredly lead to a still more satisfactory mode of preventing the unpleasant and probably noxious emanations now only too perceptible to the olfactory nerves.

5. But the most important of all the lessons we have to learn from our review of the water system of the human frame is probably the preservation from pollution of all the streams that flow amongst the living tissues. In the body, as we have seen, even the sewers, the veins, are only allowed to contain certain gaseous compounds, that are got rid of in the lungs in an imperceptible form; and I may say, in passing, that noxious as the breath is when exhaled, nothing like the canopy of unburnt coal dust contained in black smoke is ever seen to pass through our air passages. But thanks to this and other forms of purification of the blood, not the smallest particle of impurity is allowed to penetrate into the rivers of life—the arteries. This assuredly cannot be said of the English watercourses. It would be difficult to find a stream of any size that is not polluted in one way or another, and in Manchester and Salford we have only to enumerate the Irwell, the Irk, the Medlock, and the Blackbrook, to call up images of dark, inky, foul-smelling streams, little, if at all, different from main sewers. It is a case of our guardians against dirt needing guardianship themselves. The physician has to heal himself—the purifier itself needs purification.

It will no doubt be said that most of the impurity that now passes into our streams is the result of our prosperity, and that we must beware how we meddle with the progress of trade; and if it could be shown that the manufacturing interests of the country really demanded the sacrifice of our rivers, I, for one, should hesitate before refusing them this boon. If a sufficiency of water for sanitary purposes could be procured from other sources, and if there could be left a sufficient area of green space, park, and forest, to provide for the thorough purification of the atmosphere, I would willingly give up all the fish in the rivers that flow through manufacturing towns, and the birds and flowers and other delights of rural life. But these are important conditions, and they must be complied with before we give our answer.

We are now finding out (1) That means of securing a healthful life, as regards both water and air, are already sadly overweighted. (2) That the poisoning of our rivers and the pollution of the air by manufacturing products are in no way essential to the material prosperity of the country.

In support of the first assertion, it is sufficient to refer to Dr. Angus Smith's reports on the air and rain of Manchester, and to suggest that Manchester would certainly not have gone as far as Thirlmere if she could have obtained a sufficient supply of pure water nearer home. With regard to the second point, it has been proved over and over again that when manufacturers have been compelled to keep their waste products out of streams, they are usually the gainers in the end, on account of the utilisation of what had before been regarded as worthless. We may well believe that the Legislature has been influenced by considerations such as these in framing the several Rivers Pollution Prevention Acts that have been passed in recent sessions. As the Rivers Pollution Commissioners themselves state, the standard of purity that they have adopted "has been framed with the most careful regard for the interests of both towns and manufacturers;" but, thanks to these Acts, it is now illegal to permit any solid or liquid sewage matter to fall into any stream, and manufacturers are bound to use the best practicable and reasonably available means for rendering their refuse harmless before it passes into a stream. Surely this is not too much to ask! As John Taylor, "The Water Poet," wrote more than a hundred years ago—

> "Greatest in goodnesse is the river Thames,
> From whose diurnall and nocturnal flood
> Millions of soules have fewel, cloathes, and food.
>
> * * * * *
>
> Therefore 'tis great pitty shelse or sand,
> From the forgetfull and ingratefull land,
> Should its clear chrystall entrailles vilify,
> Or soyle such pureness with impurity."